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Remarks

The present invention relates to a method for etching a metal layer having an antireflective coating (ARC) layer thereon, comprising two steps. The first step generally involves dry cleaning the ARC layer with an oxide-based gas. The second step generally involves etching at least part of the metal layer with a gas mixture comprising Cl_2 and CHF_3 . The present method generally decreases microloading effects (e.g., etching a metal layer in a semiconductor device at a different rate closer to the edge of the wafer than in the center of the wafer, see, e.g., page 1, lines 5-9; page 3, lines 7-13; and page 5, line 19 through page 6, line 12 of the present specification).

The references cited against the originally-filed claims (Costaganna et al., European Pat. Appl. No. EP 0 731 501 A1 [hereinafter "Costaganna"], Hori et al., U.S. Pat. No. 5,445,710 [hereinafter "Hori"], Niino et al., U.S. Pat. No. 5,637,153 [hereinafter "Niino"], and Cain, U.S. Pat. No. 5,433,823 [hereinafter "Cain"]) neither disclose nor suggest the combination of (1) dry cleaning an oxide-based ARC layer with an oxide-based gas (such as oxygen) and (2) etching at least part of the metal layer with a gas mixture comprising Cl_2 and CHF_3 , as recited in claim 1 above. Consequently, the present claims are patentable over the cited references.

The Rejection of Claims 1-2 under 35 U.S.C. § 102

The rejection of Claims 1-2 under 35 U.S.C. § 102 as being anticipated by Costaganna is respectfully traversed.

Costaganna discloses a two-step plasma process for patterning a stack comprised of a cap SiO_2 oxide layer (15), a tungsten silicide layer (14) and a bottom polysilicon layer (13) on a silicon substrate (11) coated by a thin oxide layer (12), with a resist stripping/cleaning step therebetween (Abstract, ll. 1-7). After a resist mask (16) is formed at the top of the structure, the cap SiO_2 layer is etched in a first chamber of a multi-chamber MERIE reactor using a CHF_3 , O_2 and Ar chemistry. Then, the semiconductor structure is removed from the reactor, the resist mask is eliminated by O_2 ashing, and the wafer is cleaned (Abstract, ll. 8-14). Next, the structure

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is introduced into a second chamber of the RIE reactor, and the WSi_2 and polysilicon layers are etched in sequence using the patterned cap SiO_2 layer as a hard mask (Abstract, ll. 14-18). A mixture of HCl , Cl_2 and N_2 is adequate for tungsten silicide etching, and a mixture of HCl , He and He-O_2 is adequate for polysilicon etching (Abstract, ll. 18-20).

Costaganna does not disclose either step of the present method. Costaganna does not disclose an antireflective coating or ARC layer, much less dry cleaning an oxide-based antireflective coating with an oxide-based gas (such as oxygen). In addition, Costaganna does not disclose etching a metal layer with a gas mixture comprising Cl_2 and CHF_3 . Consequently, this ground of rejection is unsustainable, and should be withdrawn.

As discussed above, Costaganna discloses etching a cap SiO_2 oxide layer with a gas mixture containing O_2 and CHF_3 (see also col. 2, lines 31-53; and col. 6, lines 12-24). However, Costaganna does not equate the cap SiO_2 oxide layer disclosed therein with an antireflective coating or ARC layer. The art recognizes that antireflective coatings have light reflectivity-reducing properties (see, e.g., Wolf, "Silicon Processing for the VLSI Era," vol. 4, pp. 244-251, Lattice Press, Sunset Beach, California (2002); submitted herewith). These properties are not necessarily possessed by all silicon oxides (see, e.g., p. 251, lines 7-9, which suggests that an underlying oxide can be "masked" from light by a bottom layer of a multilayer ARC; if the underlying oxide was antireflective, it presumably would not need an antireflective coating between it and the overlying photoresist). Although Costaganna uses the cap SiO_2 oxide layer as a hard mask for etching subsequent layers (see, e.g., col. 9, ll. 19-22, and col. 10, ll. 7-10, 19-25 and 48-51), Costaganna is silent with regard to use of the cap SiO_2 oxide layer as an antireflective coating. Therefore, the disclosure by Costaganna of etching a cap SiO_2 oxide layer with a gas mixture containing O_2 and CHF_3 does not support this ground of rejection.

Costaganna also discloses O_2 ashing a resist etching mask over a cap TEOS layer and cleaning the wafer using DHF (100:1) to eliminate resist residues and particulates existing on the wafer surface (col. 6, ll. 19-29). This ashing step appears to be the same as the cap SiO_2 oxide layer ashing step disclosed in the Abstract of Costaganna (also see, e.g., col. 8, ll. 27-55). However, as explained above, the cap SiO_2 oxide layer of Costaganna (which Costaganna

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considers relatively thick; see, e.g., col. 1, lines 32-35 and 39-43; and col. 6, lines 10-18) is not necessarily an antireflective layer. As a result, Costaganna is silent with regard to dry cleaning an antireflective coating with an oxide-based gas, and the disclosure by Costaganna of ashing a resist etching mask over a cap TEOS layer or a cap SiO₂ oxide layer with O₂ does not support this ground of rejection.

Costaganna does not appear to disclose anything else regarding (i) etching or cleaning a material that could arguably be an antireflective layer or (ii) etching or cleaning with an oxide-based gas (such as dioxygen). Consequently, Costaganna does not anticipate the first step of the present method, dry cleaning an oxide-based antireflective layer with an oxide-based gas.

Furthermore, Costaganna does not disclose etching a metal layer with a gas mixture comprising Cl₂ and CHF₃. As discussed above, Costaganna discloses etching a WSi₂ layer using a mixture of BCl₃ and Cl₂ (col. 3, ll. 5-20) or HCl, Cl₂ and N₂ (col. 9, ll. 22-37) and a polysilicon layer using mixture of HCl, He and He-O₂ (col. 4, ll. 38-57; col. 9, ll. 40-55). Neither of these mixtures includes any fluorine-based gas. Thus, the disclosure of Costaganna that relates to etching anything that is arguably a metal layer does not teach or suggest doing so with a fluorine-based gas.

Costaganna discloses etching materials such as a cap SiO₂ oxide layer or a thin native oxide layer (formed on the surface of the polysilicon) with fluorine-based gasses such as CHF₃ or CF₄ (see, e.g., col. 2, ll. 29-53; col. 4, ll. 14-32; and col. 6, ll. 19-24). However, Costaganna does not disclose or suggest etching a metal layer with such a fluorine-based gas. Consequently, Costaganna does not anticipate the second step of the present method, etching a metal layer with a gas mixture comprising Cl₂ and CHF₃.

As a result, Costaganna does not disclose either step of the present method. Therefore, this ground of rejection is unsustainable, and should be withdrawn.

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The Rejection of Claim 3 under 35 U.S.C. § 103

The rejection of Claim 3 under 35 U.S.C. § 103 as being unpatentable over Costaganna in view of Hori is respectfully traversed.

Claim 3 depends from claim 1. Therefore, claim 3 includes the same limitations as claim 1 above. As explained above, Costaganna does not disclose or suggest (1) dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with CHF_3 . As will be explained below, Hori fails to cure these deficiencies of Costaganna. Thus, for essentially the same reasons as for claim 1, claim 3 is patentable over Costaganna in view of Hori.

Hori discloses a dry-etching method, comprising the steps of forming a carbon film on a substrate to be etched, forming a resist pattern on the carbon thin film, selectively etching said carbon film using the resist pattern as a mask by a plasma of a mixture of a fluorine-containing gas and an oxygen-containing gas to form a carbon film pattern, and selectively etching the substrate using the carbon film pattern or the resist pattern and the carbon film pattern as a mask (Abstract). Hori only discloses the carbon film as an antireflective layer (see, e.g., col. 4, ll. 61-63), and does not appear to teach or suggest that any oxide-based material therein may have antireflective properties. Therefore, Hori fails to cure the salient deficiencies of Costaganna with regard to dry cleaning an oxide-based antireflective layer with an oxide-based gas.

Furthermore, Hori teaches selective removal of organic resist and carbon films relative to metal films using fluorocarbon-containing etchants, thereby suggesting to one of ordinary skill in the art that etchants containing fluorocarbons may not be effective at etching metals. For example, Al, silicon, or a metal film were not etched at all when gas mixtures of (1) carbon tetrafluoride and oxygen or (2) carbon tetrafluoride and steam were used to etch an organic resist film on a carbon film (col. 22, l. 64 - col. 23, l. 8). In fact, a gas mixture of carbon tetrafluoride and oxygen, similar to that used to remove the organic resist, was used to selectively etch the carbon film relative to an underlying metal film (see, e.g., col. 29, l. 52 - col. 30, l. 12; col. 31, ll. 47-68). In the latter case, the carbon film was already patterned, exposing the underlying metal film (col. 27, ll. 37-54). Hori also teaches that hydrogen radicals and fluorine radicals can be

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used in place of an oxygen radical to remove the carbon film, with the same effect as the oxygen radicals (col. 38, ll. 62-66). After forming a carbon film pattern on an Al alloy film, resist ashing with CF_4/O_2 gas removed only the resist pattern from the carbon film, leaving an etching mask pattern consisting of the carbon film, and presumably not etching the underlying Al alloy film to any significant degree (col. 17, ll. 31-44). The Al alloy film was etched with a mixture of BCl_3 and Cl_2 (col. 17, ll. 45-52). Because Hori teaches the use of fluorocarbon etchants to selectively remove materials from metal layer surfaces, Hori cannot provide motivation to one of ordinary skill in the art to include a fluorocarbon such as CHF_3 in a gas mixture for etching a metal layer.

With specific regard to CHF_3 , Hori used a mixture of CHF_3 and CO to etch silicon dioxide over an Al alloy (col. 18, l. 65 - col. 19, l. 7; col. 19, ll. 38-43; col. 33, ll. 35-43). Hori suggests that other gases such as Ar, or mixtures such as CF_4 and hydrogen, can also be used to etch the SiO_2 (col. 34, ll. 20-24). In these cases, the SiO_2 was etched to form an opening to an underlying Al alloy or silicon (col. 18, ll. 36-57; col. 32, l. 62 - col. 33, l. 20). Thus, similar to the etching process for selectively removing carbon from over a metal layer, the disclosure of Hori that specifically relates to CHF_3 also teaches and/or suggests to one of ordinary skill in the art that CHF_3 is used to etch materials other than metals. As a result, Hori not only fails to disclose use of CHF_3 in a gas mixture for etching a metal layer, Hori does not provide motivation to one of ordinary skill in the art to include CHF_3 in a gas mixture for etching a metal layer.

Consequently, Hori fails to cure the salient deficiencies of Costaganna with regard to both steps of the present claim 1.

Since neither reference discloses or suggests (1) dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with a mixture containing CHF_3 , as is recited in claim 1, no combination of Costaganna and Hori can disclose or suggest (1) dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with a mixture containing CHF_3 . Consequently, this ground of rejection is unsustainable, and should be withdrawn.

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The Rejection of Claim 4 under 35 U.S.C. § 103

The rejection of Claim 4 under 35 U.S.C. § 103 as being unpatentable over Costaganna in view of Niino is respectfully traversed.

Claim 4 depends from claim 1. Therefore, claim 4 includes the same limitations as claim 1 above. As explained above, Costaganna does not disclose or suggest (1) dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with CHF_3 . As will be explained below, Niino fails to cure these deficiencies of Costaganna. Thus, for essentially the same reasons as for claim 1, claim 4 is patentable over Costaganna in view of Niino.

Niino discloses a cleaning gas containing ClF_3 , used to remove a polysilicon-based film deposited on an inner wall surface of a reaction tube, the surface of a member incorporated in the reaction tube, and an inner wall surface of an exhaust pipe system (Abstract, ll. 1-8). Niino is completely silent with regard to anti-reflective properties of materials to be cleaned or etched. In fact, an electronic word search of Niino for the term "reflect" (or any prefixed and/or suffixed variation thereof) showed no instances of any such term. Thus, Niino cannot teach or suggest that any oxide-based material therein may have antireflective properties. As a result, Niino fails to cure the salient deficiencies of Costaganna with regard to dry cleaning an oxide-based antireflective layer with an oxide-based gas.

Niino is similarly silent with regard to etching metals with CHF_3 . Niino discloses an attempt to dry clean the inside of a reaction tube with an etching gas such as carbon tetrafluoride (CF_4) to remove a film deposited inside the reaction tube (col. 2, ll. 17-24). However, Niino is silent with regard to etching metals (particularly those having an antireflective coating thereon) with CHF_3 . Thus, Niino does not teach or suggest etching a metal layer with a gas mixture containing CHF_3 . As a result, Niino fails to cure the salient deficiencies of Costaganna with regard to the second step of the present method.

Since neither reference discloses or suggests (1) dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with a mixture

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containing CHF_3 , as is recited in claim 1, no combination of Costaganna and Niino can disclose or suggest (1) dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with a mixture containing CHF_3 . Consequently, this ground of rejection is unsustainable, and should be withdrawn.

The Rejection of Claims 5-7 under 35 U.S.C. § 103

The rejection of Claim 5-7 under 35 U.S.C. § 103 as being unpatentable over Costaganna in view of Cain is respectfully traversed.

Claims 5-7 also depend from claim 1. Therefore, claims 5-7 include the same limitations as claim 1 above. As explained above, Costaganna does not disclose or suggest dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with a mixture including CHF_3 . As will be explained below, Cain fails to cure all of the deficiencies of Costaganna. Thus, for essentially the same reasons as for claim 1, claims 5-7 are patentable over Costaganna in view of Cain.

Cain discloses a process for plasma etching bi-layer passivation films comprising silicon nitride and silicon oxide using a ratio of gases selected from the group consisting of CHF_3/SF_6 , CHF_3/O_2 , and $\text{CHF}_3/\text{C}_2\text{F}_6$ (Abstract). Cain is completely silent with regard to the anti-reflective properties of materials to be etched. Similar to Niino, an electronic word search of Cain for the term "reflect" (or any prefixed and/or suffixed variation thereof) showed no instances of any such term. Thus, Cain cannot teach or suggest that any oxide-based material therein may have antireflective properties. As a result, Cain fails to cure the salient deficiencies of Costaganna with regard to dry cleaning an oxide-based antireflective layer with an oxide-based gas.

However, Cain discloses etching TiW with an etchant mixture including CHF_3 and either O_2 (col. 8, ll. 34-60) or SF_6 (col. 8, l. 64 - col. 9, l. 22). However, Cain does not equate any of the etchant gas mixtures therein (CHF_3/SF_6 , CHF_3/O_2 , and $\text{CHF}_3/\text{C}_2\text{F}_6$) with a mixture of CHF_3 and Cl_2 . Thus, Cain does not teach or suggest etching a metal layer with a gas mixture containing CHF_3 and Cl_2 , nor does Cain provide motivation to replace the gas mixture(s) therein

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with a gas mixture containing CHF_3 and Cl_2 . As a result, Cain fails to cure all of the salient deficiencies of Costaganna with regard to the second step of the present method.

Since neither reference discloses or suggests (1) dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with a mixture containing CHF_3 and Cl_2 , as is recited in claim 1, no combination of Costaganna and Cain can disclose or suggest (1) dry cleaning an oxide-based antireflective layer with an oxide-based gas or (2) etching a metal layer with a mixture containing CHF_3 and Cl_2 . Consequently, this ground of rejection is unsustainable, and should be withdrawn.

The Provisional Rejection of Claims 1-7 for Obviousness-Type Double Patenting

The provisional rejection of claims 1-7 under the judicially-created doctrine of obviousness-type double patenting in view of claims 9-15 of co-pending and commonly owned Application No. 10/749,635 (the "'635 application") is respectfully traversed.

The claims of the present application are directed to a method, while claims 9-15 of the '635 application are directed to an apparatus. Historically, the U.S. Patent Office has required restriction between groups of claims directed to these different statutory categories of subject matter (see, e.g., MPEP § 806.05(c)). Where inventions are independent, as are the present claims and claims 9-15 in the '635 application, then restriction is ordinarily proper (see MPEP § 806). When restriction is required between a process and an apparatus for its practice, then the U.S. Patent Office concludes that the different groups of claims are patentably distinct (see MPEP §§ 802.01 and 806.05(e)). If restriction is required in the '635 application, then the U.S. Patent Office must conclude that the different statutory categories of subject matter claimed in the '635 application are patentably distinct. There would not appear to be any reasonable or rational basis for concluding differently with regard to the present claims and claims 9-15 of the '635 application.

Consequently, this provisional ground of rejection is unsustainable, and should be withdrawn.

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Conclusions

In view of the above amendments and remarks, all grounds for rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,



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